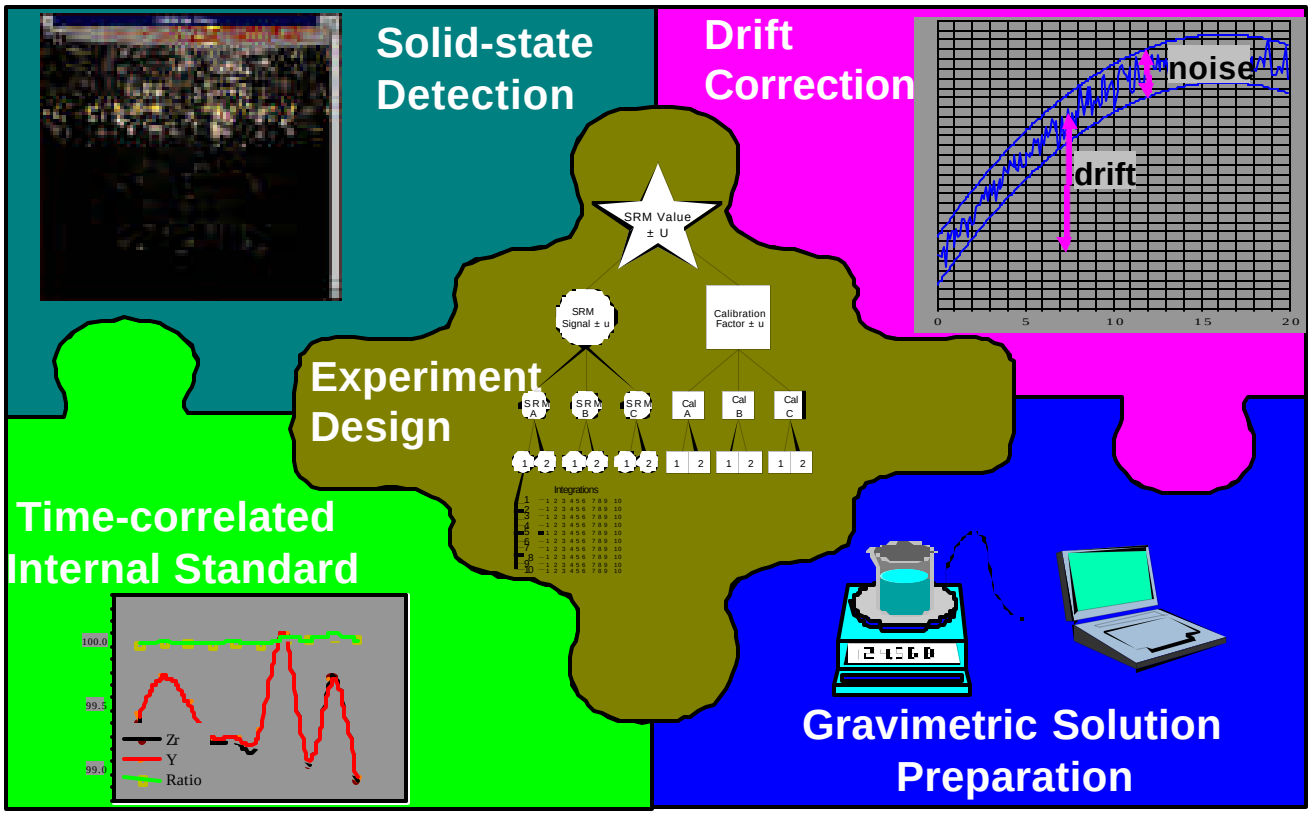
Developing New Measurement Methods/Technologies

Technical Highlights of the Analytical Chemistry Division of NIST

Methodology for High Precision ICP-OES

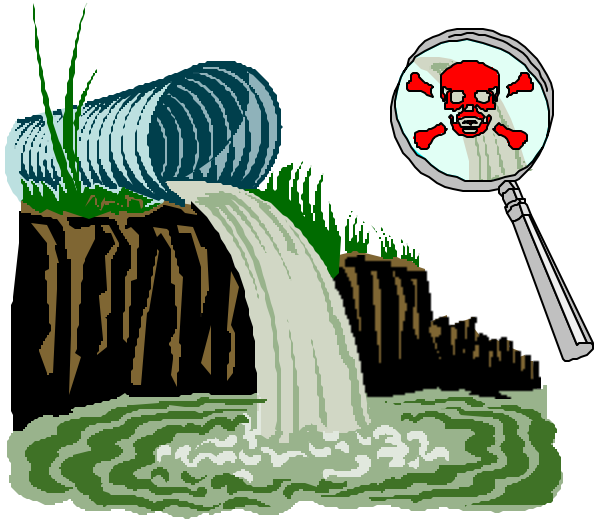


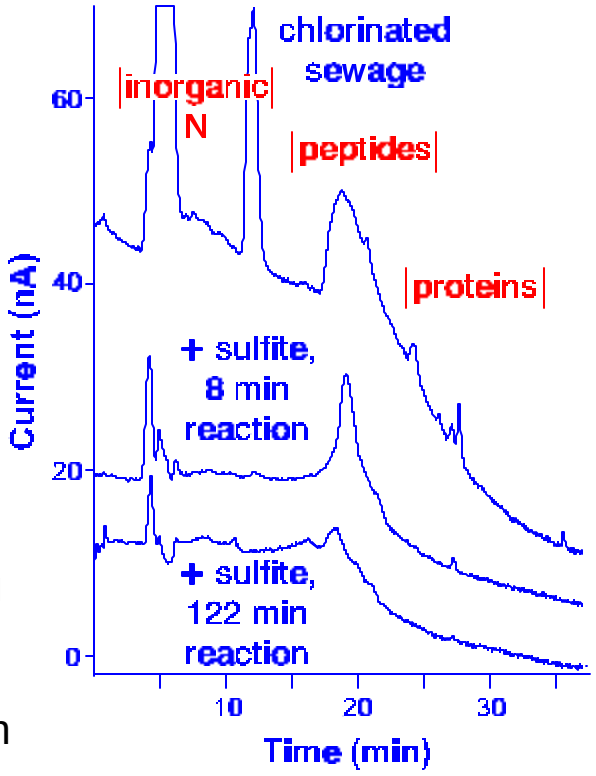
Project Description: Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) is routinely used for elemental analysis from ng/g to mg/g mass fraction levels. Modern commercial instruments are highly automated and exploit solid state detection, permitting high precision simultaneous multielement spectroscopy. This technology is combined with careful metrology to yield high precision methodology.

Results: Analytical ICP-OES results with instrumental measurement precision of several parts-per-ten thousand are being achieved, affording analyses with expanded uncertainties on the order of 1 part-per-thousand. This has been demonstrated for more than 20 elements in single and multielement analyses.

Relevance: Analytical problems which have demanded either difficult or expensive approaches (classical methods, isotope dilution) can now be performed in a highly reliable and automated fashion. More than 1000 ICP-OES instruments of this caliber are deployed in the world, and this methodology is transferable to these installations.

Monitoring Toxic Chlorination Products in Sewage Wastewater





Project Description: To develop new measurement technology for monitoring the effectiveness of chlorine removal processes in sewage wastewater disinfection. Liquid chromatography with post-column reaction/electrochemical detection (LCEC) is being used to determine the toxic organic N-chloramines formed in wastewater.

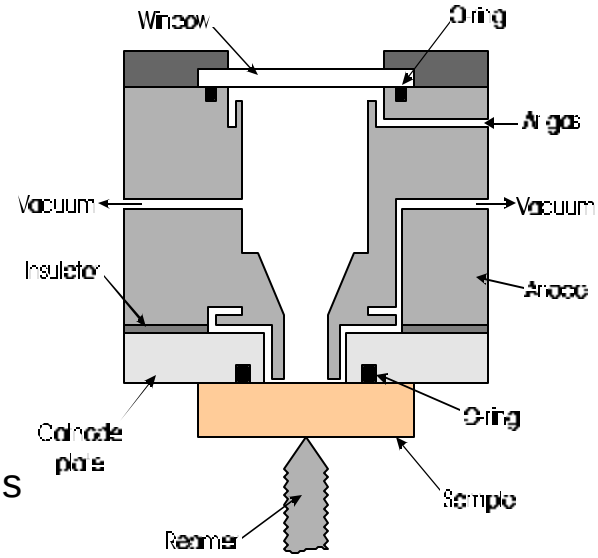
Results: The LCEC method was used to determine that organic N-chloramines react slowly with the sulfite added for removal of residual chlorine from the disinfection process. By comparison to model compounds, it was determined that the organic N-chloramines in the wastewater are likely to be peptides and proteins. Based on these observations, longer process dechlorination times may be required.

Relevance: Measurements of dechlorination-resistant N-chloramines will aid in the design and implementation of more effective chlorine removal processes. Lower residual chlorine will help minimize the toxic impact of the 40 billion gallons of sewage wastewater discharged every day into US waterways.

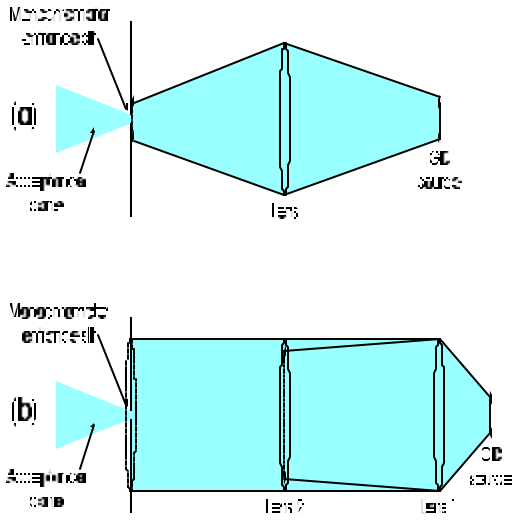
Optically Induced Analytical Error in Glow Discharge Optical Emission Spectrometry (GD-OES)

GD-OES:

- an important industrial method for the determination of the elemental composition of solids such as metals and alloys and more recently, of ceramics, glasses, polymers and thin films
- far less dependent on matrix-matched standards than other techniques typically used in the US for these measurements
- a promising technique for NIST analysis of non-metals in advanced materials



Fundamental and practical aspects of the technique for use in quantitative analysis are being studied in collaborative work with academic and commercial instrument developers.

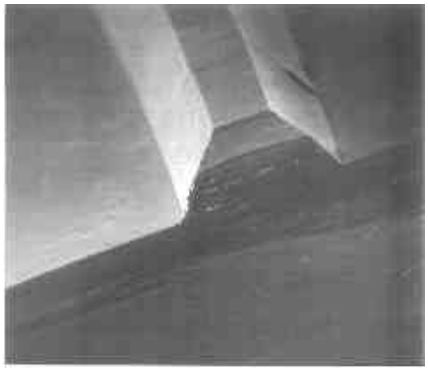


- If the solid sample is heterogeneous, use of a single lens, as shown to the left in figure (a), may induce analytical errors of up to 2 % or more.
- The use of two lenses as shown in (b) completely eliminates this error.

- Further characterization of GD-OES with the two lens system is underway to assess and improve its reliability for quantitative chemical analysis.

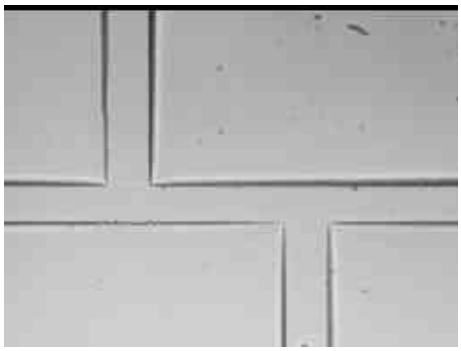
Fabricating Plastic Microfluid Systems for Use in Analytical Chemistry

SEM Image of Silicon Template for Imprinting



courtesy of John Small, NIST

Imprinted Microchannel

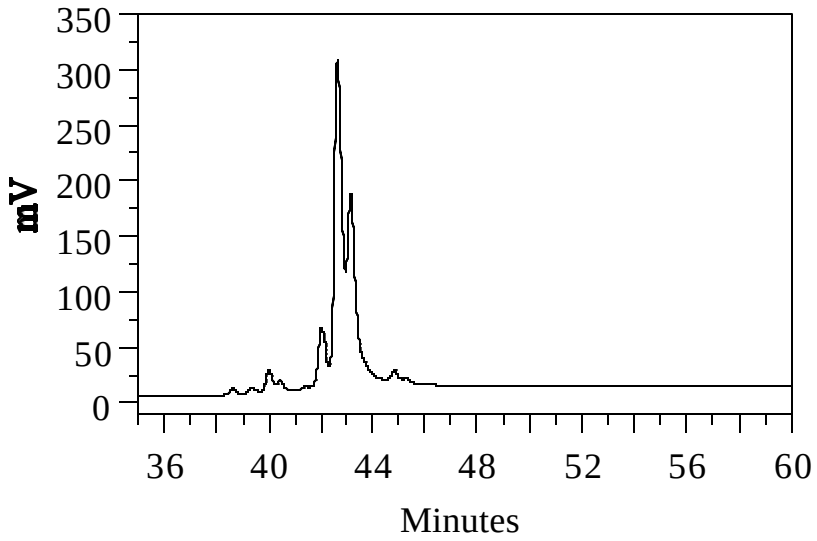


Project Description: New program that focuses on identifying and overcoming barriers to the use of microanalytical devices for quantitative measurements. Initially, new techniques for the fabrication of microfluid networks suitable for use in microanalytical systems are being developed.

Results: Plastic microfluid channels were prepared by the wire-imprinting and silicon template imprinting protocols. Device-to-device reproducibility was excellent. Plastic microfluid devices with channel dimensions of 25 μm were used to perform rapid electrophoretic separations.

Impact: The introduction of simple, cost-effective alternatives for the fabrication of microfluid devices should increase the accessibility of this rapidly-growing technology in the analytical community.

Mass Spectrometry as a Tool for the Characterization and Standardization of Clinical Immunoassays: Characterizing Antibodies by LC/MS



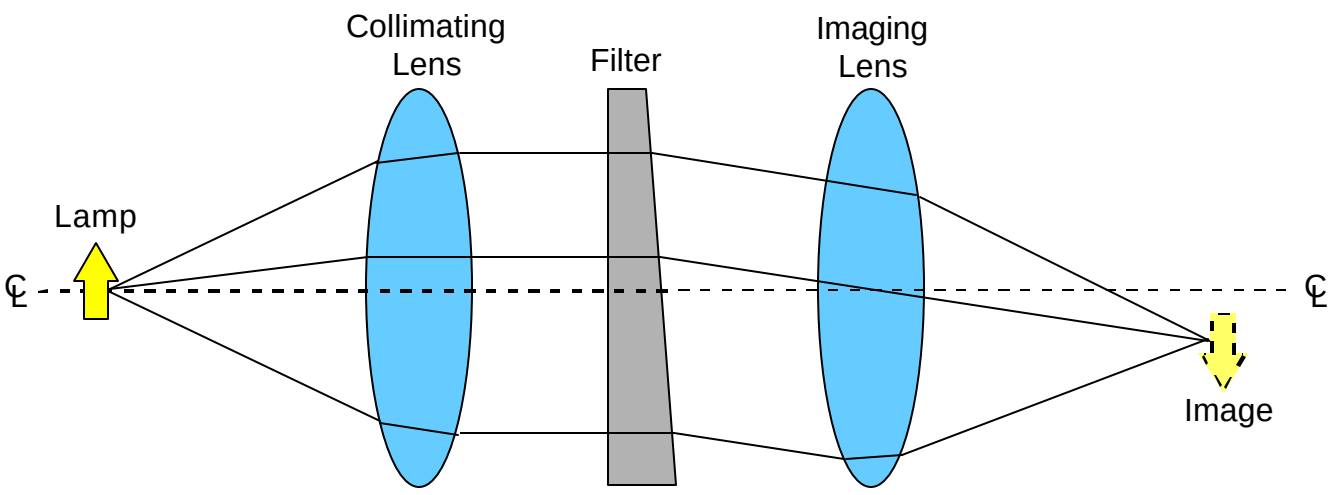
Reversed-phase LC of antibody Fab fragments at elevated temperature (60 °C).

Project Description: To develop techniques for the structural characterization of monoclonal antibodies using electrospray ionization mass spectrometry (MS) coupled with liquid chromatography (LC).

Relevance: Increasingly, the medical community is relying on immunoassay for diagnostic testing. Structural heterogeneity of the monoclonal antibodies used in immunoassays can adversely affect the accuracy of the assay. No techniques are currently available that can provide a rapid and accurate assessment of the heterogeneity of these molecules.

Results: Rapid and accurate techniques were evaluated using LC/MS with proteolytic digests, enzymatic deglycosylation, and affinity chromatography. Improvements were made in the performance of reversed-phase LC for antibody fragments by performing separations at elevated temperature. With improvements in the chromatography, the LC/MS of antibody fragments revealed information regarding antibody structural heterogeneity.

Optical Wedge in SRM Filters



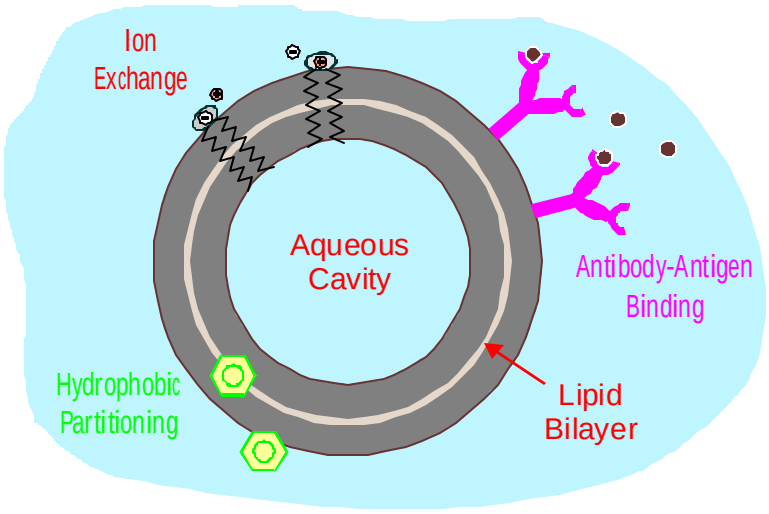
Project Description: To remedy the sensitivity of a new generation of "reverse geometry" diode array UV/visible spectrophotometers to small optical wedge angles (~ 1 arc minute) in solid optical filter standards. Collimated beam geometry is used in order that focusing onto the spectrometer slit be independent of sample thickness.

Results: The problem results from a combination of the collimated beam geometry and (deflected) imaging of the source (see illustration) onto the entrance slit to the spectrometer. A diagnostic tool based on the optical principles responsible for the problem was assembled to reject solid filter standards with wedge exceeding 20 arc seconds.

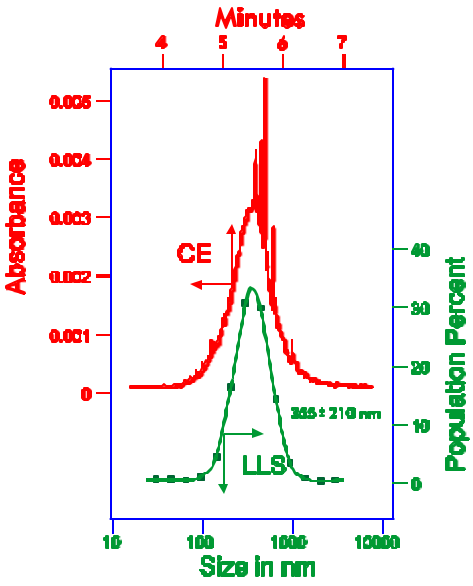
Relevance: Approximately 20% of spectrophotometers currently installed utilize diode array technology. This percentage may well increase due to the real time advantage of snapshot spectral acquisition for applications such as chemical process control and monitoring of reaction kinetics. Solid filter standards are a simple and cost effective means of validating the performance of such instruments to satisfy regulatory and quality assurance demands.

Characterization of Liposomes by Capillary Electrophoresis

Liposomes as Pseudo-Solid Reaction Phases



Comparison of CE Data with Laser Light Scattering

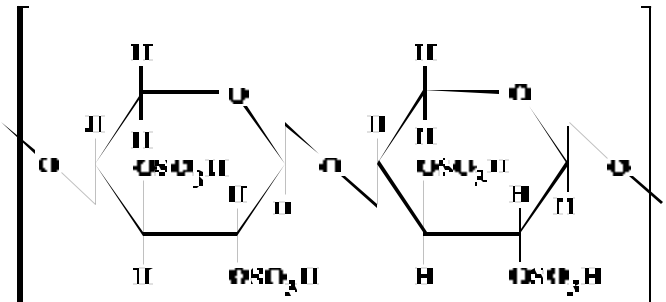


Project Description: Increasing industrial use of liposomes requires new tools for characterization and quantitation of these unique materials.

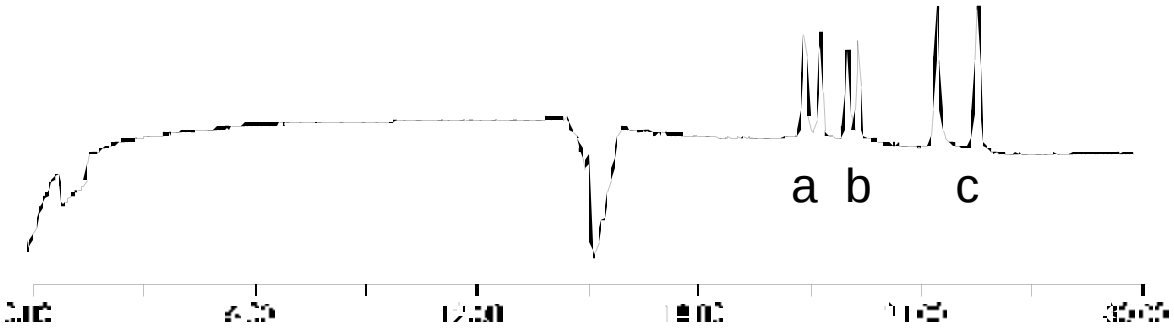
Results: CE used to characterize charge, size distribution, lysis and pseudo-stationary phase behavior of a test liposome preparation. Artifact “spike” behavior and analytical figures of merit were evaluated.

Impact: CE information contributes to the development of new liposome technology for cosmetic, pharmaceutical, and analytical applications.

Identification of New Carbohydrate-Based Chiral Selectors for Capillary Electrophoresis



pentosan polysulfate



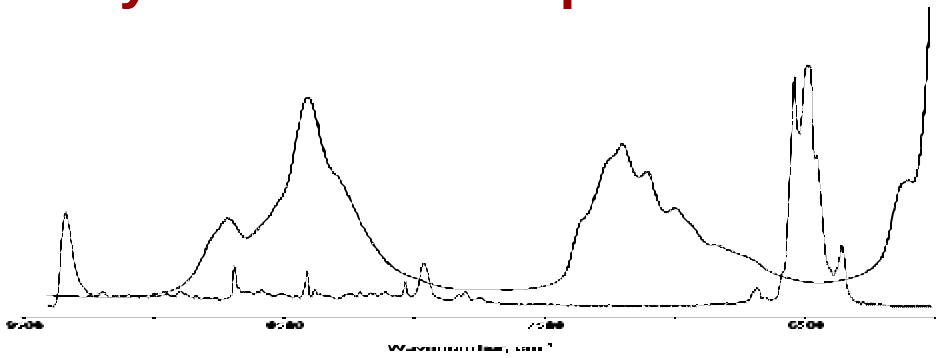
Enantiomeric resolution of three pharmaceutical compounds: (a) doxylamine, (b) bupivacaine, and (c) tetramisole

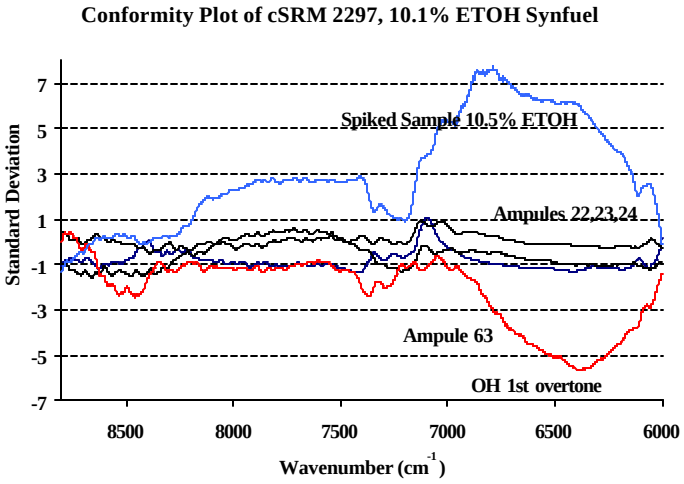
Project Description: In an ongoing program to support the development of reference materials with chiral information, ionic carbohydrates were investigated for use as chiral selectors for the separation of enantiomers by capillary electrophoresis.

Results: Pentosan polysulfate, an ionic polysaccharide, was identified as a useful chiral selector for the enantiomeric separation of antimalarials, antihistamines, and ∃-blockers.

Relevance: Separation and quantification of enantiomers is an analytical requirement for the development of chiral drugs and agrochemicals, the provision of data needed for regulatory approval of these materials, and monitoring of their production and use.

Quality Control of Ampouled Materials





Project Description: To develop tools for value-assigning individual ampoules of Standard Reference Materials or identifying outliers for discard prior to batch certification

Results: Developed hybrid NIR/Raman instrument for real-time nondestructive analysis of oxygenate concentration in individual unopened ampoules of Oxygenate in Gasoline SRMs

Relevance:

- Permits 100% quality validation of individual ampoules of SRM
- Method is being evaluated for on-line monitoring of refinery blending operations